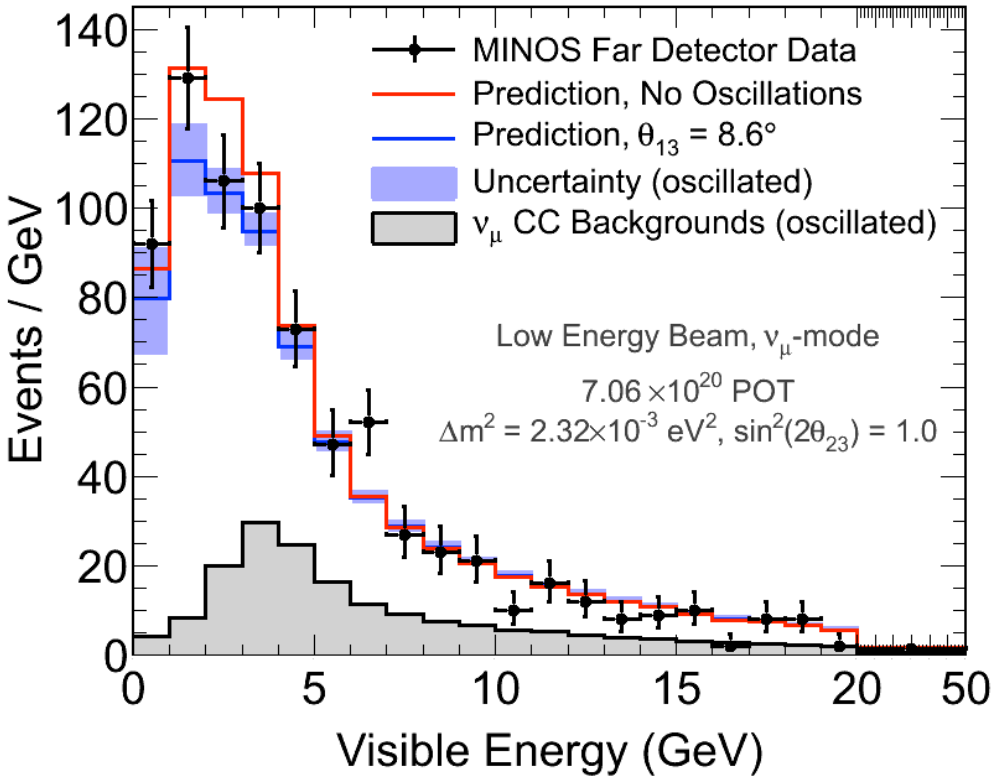
MINOS Search for Sterile Neutrino Mixing

- Transitions of active neutrino flavors to sterile neutrinos would result in a deficit of neutral current events observed at the MINOS Far Detector.

- Observed MINOS neutral current spectrum is shown on the right, along with spectra predicted from the Near Detector for oscillations among three active neutrinos with ν_e appearance set at the global fit value from *P. A. N. Machado et al., Journal of High Energy Physics, 2012, Number* ***5****, 23.*

- Agreement between the observed and predicted neutral-current spectra is quantified using the statistic *R*, tabulated on the right for different ranges of the calorimetrically reconstructed energy E_{reco}.

$$R = \frac{N_{\mathrm{Data}} - \sum B_{\mathrm{CC}}}{S_{\mathrm{NC}}}$$



E_{reco} (GeV)	N_{Data}	S_{NC}	$B_{\mathrm{CC}}^{\nu_\mu}$	$B_{\mathrm{CC}}^{\nu_\tau}$	$B_{\mathrm{CC}}^{\nu_e}$
0 – 3	327	245.6	32.5	3.2	2.7 (12.4)
3 – 200	476	267.8	157.4	9.3	30.6 (44.7)
0 – 200	803	513.4	190.0	12.5	33.2 (57.0)
0 – 3	$R = 1.14 \pm 0.07 \pm 0.08$				
3 – 200	$R = 0.99 \pm 0.08 \pm 0.06$				
0 – 200	$R = 1.06 \pm 0.06 \pm 0.06$				

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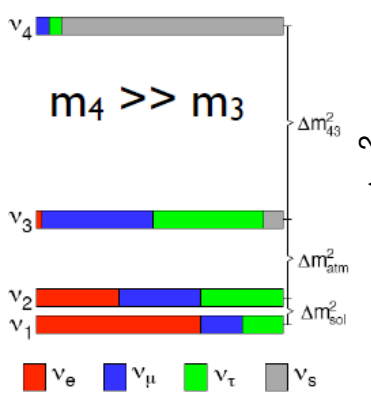

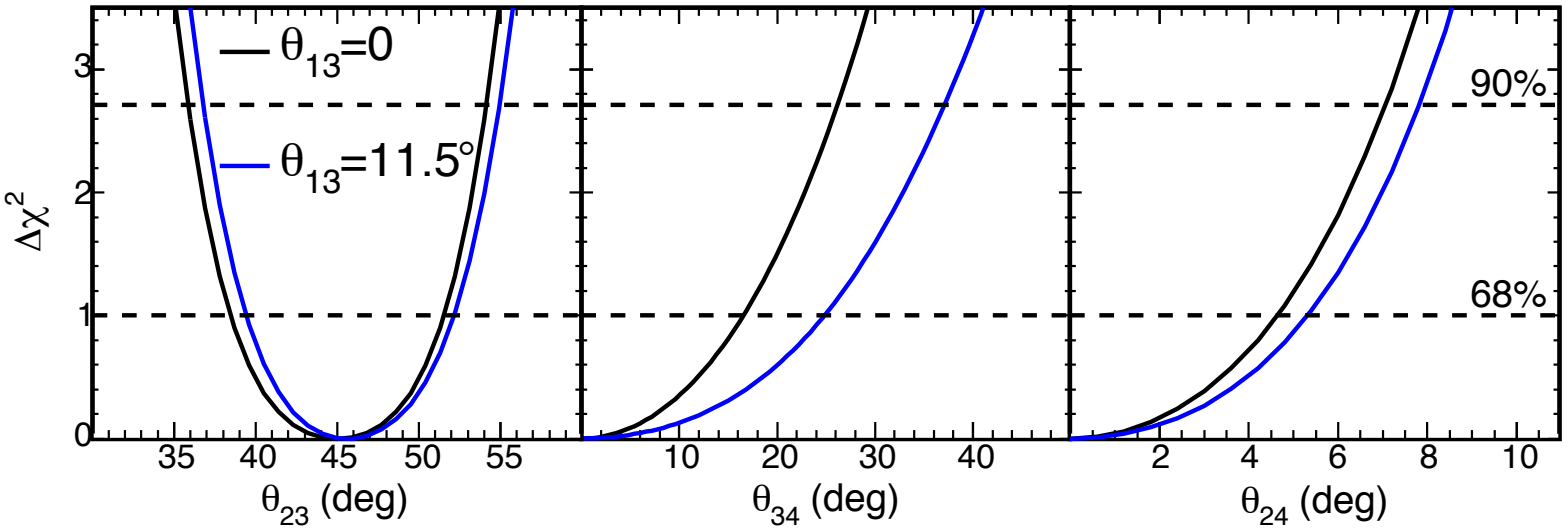

Model	θ_{13}	χ^2/d.o.f.	θ_{23}	θ_{24}	θ_{34}
$m_4 \gg m_3$	0	130.4/122	45.0^{+7}_{-7}	$0.0^{+5}_{-0.0}$	$0.0^{+17}_{-0.0}$
	11.5	128.5/122	45.6^{+7}_{-7}	$0.0^{+5}_{-0.0}$	$0.0^{+25}_{-0.0}$

- 90% C.L. Limits from 1-D Δχ2 projections

$\theta_{34} < 26°$ (37° ν_e) (90% C.L.)

$\theta_{24} < 7°$ (8° ν_e) (90% C.L.)

- Results of fitting the data with a 3+1 model including one sterile neutrino and a new mass eigenstate ν_4. Stringent constraints are placed on the sterile mixing angles.
- This 4-flavor analysis is being refined with the inclusion of Near Detector oscillations, relevant for values of $\Delta m^2_{43} > 1$ eV^2. Results are expected in Summer 2012.
- The new model has been used to assess the reach of MINOS+ in excluding sterile neutrino mixing, as shown in the next slide.

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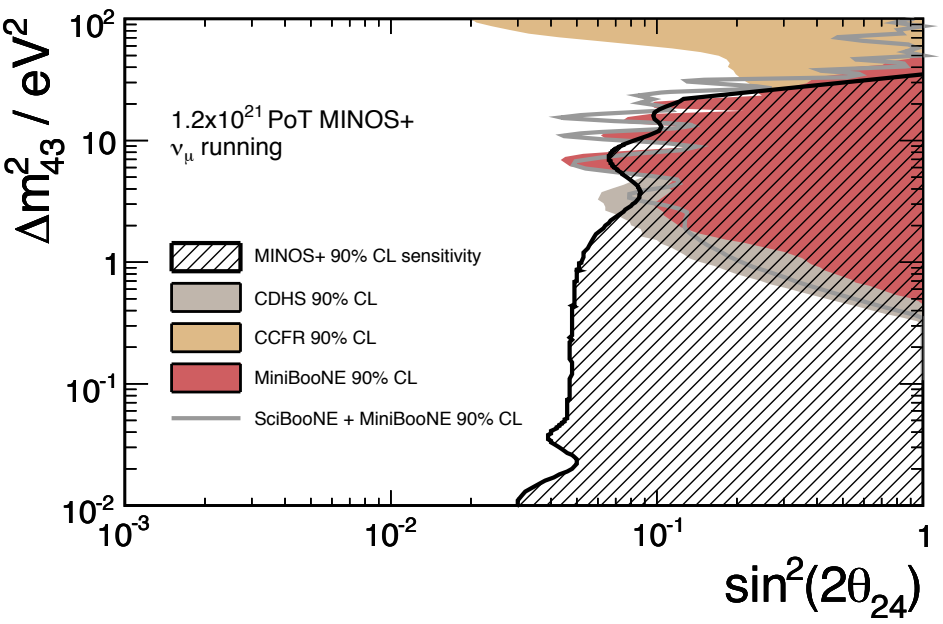

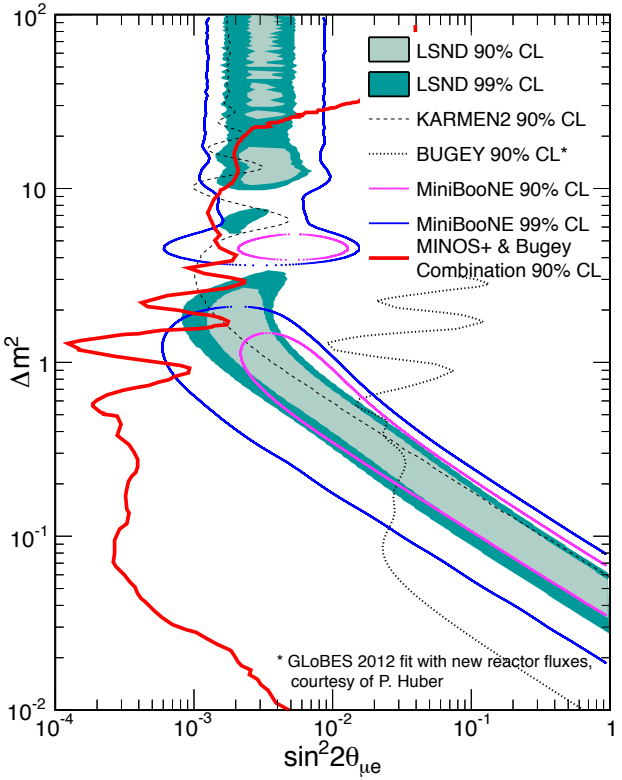

- MINOS+ 90 % CL exclusion of $\sin^2(2\theta_{24})$ compared to MiniBooNE, CDHS, and CCFR ν_μ disappearance results. The MiniBooNE, CDHS, and CCFR contours come from Phys. Rev. Lett. 103 (2009) 061802 and show the MiniBooNE disappearance result. The Δm^2 value for CDHS, MiniBooNE and CCFR is for mass states m2 and m4. Because $m_4 >> m_3$, Δm^2_{42} is nearly the same as Δm^2_{43}.
- MINOS+ and Bugey combined 90% CL limit on the sterile parameter $\sin^2(2\theta_{\mu e})=4|U_{e4}|^2|U_{\mu 4}|^2$, obtained from the disappearance limits of each experiment on the size of $|U_{\mu 4}|^2$ and $|U_{e4}|^2$. The Bugey limit is computed from a GLoBES 2012 fit provided by P. Huber.
- The combined limit excludes large portions of the LSND signal region.